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# UNIVERSITY OF ILLINOIS, Agricultural Experiment Station.

URBANA, JANUARY, 1897.

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## BULLETIN No. 46.

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### EXPERIMENTS WITH CORN, 1896.

Of the many experiments with corn that are in progress at this Station but two are reported in the present bulletin, other apparent results being held for further confirmation.

For the benefit of those who desire to consider the effect of meteorological conditions upon the experiments reported, there is given on the next page a table of temperatures and rainfall as observed at this station from January, 1889, to December, 1896, inclusive.

#### *Experiment No. 9. Depth of Cultivation.*

PLANTING.—For the purpose of continuing experiments in cultivation, a small field was planted May 11th to a variety known as Burr's white, and immediately divided into ten plats lying side by side, each eight rows in width, twenty-four in length, and well protected by marginal plantings. The field was longest from north to south and plat 1 was at the north end.



## METEOROLOGICAL RECORDS, 1889-1896.

## TEMPERATURE, DEGREES, FAHRENHEIT.

	January.			February.			March.			April.		
	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.
1889	29.28	57	-2	23.36	53	-7.5	39.92	72	18	51.9	75	25
1890	33.5	66	-5	34.66	68	7	33.35	61	2	52.32	81	29
1891	30.26	57	6	30.45	61	-9	32.55	65	-1	52.78	81	22
1892	19.2	57	-15	33	55	*	36.1	69	*	48.6	70.5	26
1893	14.8	48	*	25.8	51	*	37.8	76	*	49.3	75	30
1894	29.4	64	-21	24.7	58	-5	43.5	77	10	51.4	85	25
1895	19.5	57	-8	17.9	65	-20.5	35.9	84	7	52.3	88	27
1896	28.1	52	-5	29.6	68	-4	34.4	67	6	57.6	86	21
Whole period..	25.5	66	*-21	27.43	68	*-20.5	36.69	84	*-1	52.02	88	21

  

	May.			June.			July.			August.		
	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.
1889	59.2	91	28	65.5	88	40	72.7	90.5	50	69.2	89	29.5
1890	58.27	87	33	74.56	96	47	73.02	97.5	45	68.74	96	44.5
1891	58.4	91	30	71.9	93	49	70.12	93	42	70.21	99	40
1892	57.9	82	36	70.6	94	51	73.3	96.5	46	71.5	94	47
1893	57.4	84	37	70.5	93	53	76.4	98	48	71.1	96	37
1894	59.6	89	32	73.4	97	34	73.8	98	47	72.3	99	41
1895	59.4	95	28	73.3	98.5	42	71.3	94	43	73.2	97	48
1896	68.2	91	45	70.2	92	49	73.8	95	49	72	97	44
Whole period..	59.79	95	28	71.24	98.5	34	73.05	98	42	71.03	99	29.5

  

	September.			October.			November.			December.		
	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.
1889	61.32	87.5	32	47.26	82	25	36.82	62	4	42.71	66	15
1890	60.46	89	33	52.07	76	27	42.62	68	21	30.91	58	8
1891	69.2	96	41	51.3	88.5	27	35.69	67	2	37	60	11
1892	63.9	87	42	53.6	88.5	19	34.8	64	7	27.7	60	-7
1893	66.5	97	31	53.3	84	18	37.3	75	6	30	63	-6
1894	65	94	38	51.9	84	28	35.9	67	12	32.9	59	-4
1895	67.7	94	32	45.9	75	12	38.2	73	4	31.1	59	-2
1896	61.9	91	30	48.8	79	24	39.9	74	9	33.3	62	8
Whole period..	64.49	97	30	50.51	88.5	12	37.65	75	2	33.20	66	-7

## RAINFALL, INCHES.

	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1889	1.48	2.08	1.61	.61	5.52	6.81	5.81	.60	2.74	1.42	4.38	1.82	34.88
1890	5.26	1.87	2.70	4.11	3.56	3.80	2.83	1.93	1.19	2.35	1.63	.53	31.28
1891	.99	2.60	3.55	3.54	.89	2.08	1.41	2.86	.41	1.29	5.58	1.05	26.73
1892	.79	2.64	2.59	6.45	7.86	5.36	2.50	2.45	.93	.93	4.95	1.62	39.05
1893	1.05	4.48	3.20	7.68	4.83	1.55	.59	.06	3.62	1.14	2.98	1.09	32.37
1894	1.95	1.32	2.41	1.86	3.32	1.78	1.08	2.06	4.21	.51	2.77	1.44	24.72
1895	1.36	.52	.70	2.42	2.20	2.24	3.61	1.81	5.27	.21	3.07	5.71	29.12
1896	1.12	1.95	1.22	1.89	5.62	2.98	7.87	3.74	5.84	.42	2.87	.39	35.91
Ave. . .	1.75	2.18	2.24	3.57	4.22	3.32	3.21	1.94	3.02	1.03	3.53	1.70	31.75

\* Record incomplete.



**CULTIVATION.**—Plat 4 was cultivated one inch deep; plat 6, two inches; plat 7, four inches; plat 9, six inches; and plats 2, 5, and 8, three inches deep, all with a harrow-toothed cultivator that could be accurately adjusted to the specified depths. As a check, plat 1 was left uncultivated, but heavily mulched; plat 3 was left uncultivated, except that weeds were removed with a hoe; and plat 10 was deeply worked with a double shovel plow. The eight cultivated plats were worked upon the same days, viz., May 26th, June 6th, June 17th, and June 25th, and plat 1 was mulched with grass six inches deep on the day of the first cultivation.

**HARVESTING.**—After removing margins each plat was divided, November 23d, into four sections and each quarter harvested separately. In this manner one plat was not finished before another was commenced, but the work was done by quarters in regular succession from 1 to 10. A further advantage of this method of harvesting is to discover if any section of any plat is particularly deficient in stand.

Table 1 gives treatment of each plat together with relative location, yields by quarters expressed in pounds of ears, and total yields per acre, allowing 75 pounds of ears for one bushel of shelled corn.

TABLE 1. TREATMENT AND YIELD IN POUNDS OF EARS PER QUARTER PLAT, AND IN BUSHELS OF GRAIN PER ACRE.

Plat.	Treatment.	First quarter.	Second quarter.	Third quarter.	Fourth quarter.	Yield per acre, bu.
1	Mulched 6 inches.....	110¼	98¼	104½	106¾	94.3
2	Cultivated 3 in. deep.....	99½	94½	96¼	93	86.2
3	Uncultivated.....	97	97¼	95¾	96¾	87
4	Cultivated 1 in. deep.....	93¾	94	94¾	97¾	85.5
5	Cultivated 3 in. ".....	86½	89¾	94¾	91¾	81.6
6	Cultivated 2 in. ".....	90¼	91¼	90¾	92½	82
7	Cultivated 4 in. ".....	87½	95½	96	91¾	83.4
8	Cultivated 3 in. ".....	93½	89	100½	96¼	85.3
9	Cultivated 6 in. ".....	89½	92	96	106	86.3
10	Plowed (shovel plow).....	84½	88¾	92½	93½	80.7

**DISCUSSION.**—It would be difficult indeed to construct a table that would show greater indifference to cultivation. The highest yield was on the plat that was mulched, the next highest on the one that was entirely uncultivated, and the next upon plat 9, cultivated six inches deep.

A close study of the yield by quarters does not reveal any particularly poor spot, although in general the middle of the field shows a tendency to slightly lower yields. Nor can this tendency be connected with any particular treatment. It is true that this same land had been used for two seasons before for the "time plant-

ing" experiments, and the early plantings had been on plats 1 and 2, and the latest on plats 9 and 10. As both extremes of planting had given minimum yields, it is therefore apparent that the plats along the middle of the field had for two years previous given larger crops, and were for that reason less able to produce maximum yields under conditions equal with the others. If this be considered, these slight differences tend to disappear, and if not, they are unexplainable on the basis of this experiment. In any event the comparatively low yield of plat 10 is unaccountable, unless it be attributed to the severe action of the shovel plow or to an irregular row of pine trees some four rods to the south. Being less than twenty-five feet high, however, they cast no shade over the plat and their roots could not have reached it.

Hitherto at this Station shallow cultivation has quite uniformly proved most effective, but it must not be forgotten that the present season was one of almost ideal conditions as to moisture. Rains, copious, but not excessive, were well distributed throughout the growing season, and on the deep prairie soil of this field the necessity for cultivation of any kind beyond removal of weeds seemed to have been reduced to a minimum, if not entirely obliterated.

*Experiment No. 1. Tests of Varieties. [Methods of Experiment.]*

The principal difficulty confronting the experimenter is so to control conditions that the results obtained may be credited to the proper cause. For many years the Station has grown a large number of varieties of corn, not only to note any and all peculiarities, but more especially to test their ability to yield and their consequent value for cultivation.

Of necessity, areas employed must be small, and such yields will always be open to the objection of unlimited crossing. It has been learned, however, that these disturbances to yield are not serious in the season of the first cross, and may be fairly disregarded if fresh seed be employed each year.

Certain facts ultimately led to the suspicion that results were greatly disturbed by simple differences in soil. It had been supposed that reducing the size of plats and bringing them correspondingly closer together would tend to eliminate soil differences and that by choosing unusually uniform land such differences would be practically eliminated.

In 1895 seventy-two varieties were tested on plats <sup>two</sup> ~~ten~~ rods square. One of the varieties was repeated on thirteen different plats, and although the ground chosen was an exceedingly uniform

piece of prairie, ten by forty rods in extent, the difference in yield of the same variety on neighboring plats was startling. Without going into minutiae it will be sufficient to say that the yields of the same variety within the limits specified varied from 45.8 bushels to 100.8 bushels, and that yields on contiguous plats varied from 65.3 bushels to 89.7 bushels per acre. These differences, due to causes other than variety, represent very nearly the extremes of yield among all the varieties on all the plats; from which we may conclude that differences in soil, even on selected locations, are nearly as great as the differences between the varieties whose yields we propose to test.

Evidently some method must be devised whereby these soil differences may be eliminated or their effects neutralized, or it is more than useless to institute tests of comparative yields, not only in corn experiments, but along other and similar lines of work.

In variety tests the time element affords no relief, and as an experiment the following plan was employed:

It was first discovered that variations in yields secured from small plats are vastly greater than from larger areas, because the greatest variation noted on contiguous tenth-acre plats growing the same variety was less than ten bushels per acre, or about 12 per cent., whereas fortieth-acre plats lying contiguous showed variations of over 24 bushels, or more than 37 per cent. Plantings were therefore made in plats or strips 38 rods long to neutralize soil variation in one direction, and the same variety was repeated on every third strip for a standard by which to eliminate lateral differences. At the time of harvesting one rod was cut from each end and the strips as remaining, 36 rods long, were each harvested in six separate sections of six rods each to catch abnormal spots.

Table 2, next page, shows the varieties employed, the manner of planting by repeating one variety, Burr's white, in each ~~fourth~~ <sup>third</sup> strip, and the yield in pounds of ears of each section of each strip, together with the comparative yields expressed in bushels per acre.

Manifestly something is wrong with the first section of some of the strips. (See Iowa silver mine, Clark's Iroquois, Edmonds, and others.) As a matter of fact, vacancie; were common in this end of the field, and in final computation the first or south section of all varieties was disregarded and results were computed on the basis of yields secured from the other five.

It yet remains to translate the meaning of the last column and make the yields comparative for the same pieces of ground. The method of accomplishing this is illustrated and the computed yields given in table 3, next page.



TABLE 2. VARIETIES, ORDER OF PLANTING AND YIELD OF EACH EXPRESSED IN POUNDS OF EARS FOR EACH SECTION, AND AS TOTAL. ALSO ACTUAL YIELD PER ACRE IN BUSHELS.

Varieties.	Sections.							* Bu. per acre.
	First.	Second.	Third.	Fourth.	Fifth.	Sixth.	* Total.	
Burr's white .....	99.25	98.5	97	105	104	99.5	504	90.4
Boone county white..	117.5	139.25	125.5	124	126.25	121.75	636.75	107.4
Champion white pearl	81.25	85	83.5	84.5	82	82	417	74
Burr's white.....	93.25	106.25	105.5	109	110.25	109.5	540.5	96.9
Iowa silver mine.....	78	110.5	107.75	118.5	105.75	104.5	547	97.4
Flint.....	49.5	45.75	42	46.75	45	43	222.5	37.2
Burr's white.....	97.5	108	109.25	118.5	109.75	99.5	545	97.7
Leaming.....	97.75	131.75	118	131.75	122.75	113	617.25	106.8
Clark's Iroquois .....	66	98.5	98	95	78.5	81.25	451.25	81.1
Burr's white.....	81.75	100	109	110.5	101.25	104	524.75	94.1
Legal tender.....	90.75	106	102.5	117.25	105	104.25	535	96.
Murdock .....	90.25	93.25	93	104	90.25	93.25	473.75	84.1
Burr's white .....	100.25	107	96	99.5	103.25	83	488.75	87.7
Edmonds .....	77	85.75	87.5	85.75	90.25	83	432.25	79.1
Riley's favorite .....	88	97	105.75	105.75	108.5	87.25	504.25	92.8
Burr's white .....	84.75	104	102	109.75	97	91.75	504.5	90.5
Golden beauty .....	83.75	95.25	96.25	102	88.5	90.25	476.25	83.6
Burr's white .....	93.5	97.25	99.25	100.5	103.25	93	493.25	88.5

\* Computed from last five sections. See below.

TABLE 3. FOR COMPUTING COMPARATIVE YIELDS. [Column 1, actual yields of each variety on its plat; column 2, computed yields of Burr's white for each plat and therefore over all the field; column 3, comparative yields of varieties computed for the entire field.]

Plat.	Variety.	1	2	3
1	Burr's white .....	90.4	90.4	92.7
2	Boone county white.....	107.4	92.6	107.5
3	Champion white pearl.....	74	94.7	72.4
4	Burr's white .....	96.9	96.9	.....
5	Iowa silver mine .....	97.4	97.2	92.9
6	Flint.....	37.2	97.4	35.4
7	Burr's white .....	97.7	97.7	.....
8	Leaming.....	106.8	96.5	102.6
9	Clark's Iroquois.....	81.1	95.3	78.9
10	Burr's white .....	94.1	94.1	.....
11	Legal tender.....	96	92	96.7
12	Murdock .....	84.1	89.8	86.8
13	Burr's white .....	87.7	87.7	.....
14	Edmonds.....	79.1	88.6	82.8
15	Riley's favorite.....	92.8	89.6	96
16	Burr's white.....	90.5	90.5	.....
17	Golden beauty.....	83.6	89.5	86.6
18	Burr's white .....	88.5	88.5	.....
Average .....		.....	92.7	.....

Column 1 restates the actual yield of each variety on its plat. Column 2 is computed for Burr's white only and is intended to exhibit the probable yields of each plat if Burr's white had been planted over all the piece. The method is evident and rests on



the assumption, not quite correct, that the gradation from one strip to the third beyond is practically gradual. The average of this column (2) shows the computed yield for Burr's white over all the piece. In column 3 the yields of each variety are corrected, being raised or lowered upon the percentage basis according as the computed yield of Burr's white on that plat is above or below the average. This eliminates almost completely errors of yield due to differences of ground and exhibits what each variety would have yielded had it occupied the whole field. The yields are therefore strictly comparable, except for the fact that the varieties must have varied in the per cent. of moisture which was not determined, 56 pounds of shelled corn being taken as one bushel.

TABLE 4.

Variety.	Where seed may be obtained.	Yield per acre, bu.	Per cent. of cob.	Av. weight of ears, lb.
Burr's white .....	F. E. Burr, Philo, Ill. ....	92.7	16.3	.58
Boone county white ...	James Riley, Thorntown, Ind.	107.5	21.3	.75
Champion white pearl..	J. C. Suffern, Voorhies, Ill..	72.4	17.2	.57
Iowa silver mine.....	Ia. Seed Co., Des Moines, Ia.	92.9	16.9	.60
Flint .....	.....	35.4	21.9	.26
Leaming .....	E. E. Chester, Champaign, Ill.	102.6	19.2	.70
Clark's Iroquois.....	H. H. Clark, Onarga, Ill. ...	78.9	16.1	.58
Legal tender .....	Nims Brothers, Emerson, Ia.	96.7	16.2	.60
Murdock .....	C. H. Mills, Champaign, Ill.	86.8	17.2	.46
Edmonds .....	H. P. Edmonds, Taylor, Ill..	82.8	14.6	.53
Riley's favorite ....	James Riley, Thorntown, Ind.	96	14.1	.58
Golden beauty.....	Barnard & Co., Chicago ....	86.6	18.1	.52

W. J. FRASER, B. S., *Assistant Agriculturist.*

## CRIMSON CLOVER.

The dry summer of 1893 and 1894 gave rise to much difficulty in seeding to red clover, and attention was quite generally directed to the crimson clover as a possible substitute. This, with the numerous inquiries by letter, induced the Station to undertake some trials of its usefulness as an agricultural crop for Illinois.

Efforts to secure a stand met with but partial success, although attempts were made under a great variety of conditions. Sowings made in summer uniformly suffered from lack of moisture, and even August and September proved little more favorable, because even a slight shower provided sufficient moisture to cause the seeds to sprout, but not enough to sustain growth.

If sown in early spring a better stand was secured, but the crop hastened to maturity with but a small growth and a light yield. The small amount that started from fall seedings appeared in most cases to live and to take on a satisfactory growth in the succeeding spring. But in every case the stand was uneven and far too poor for a profitable yield. In the meantime numerous letters asking for the best method of seeding to crimson clover showed that public interest was not abating.

For the purpose of collecting information as to experience over the state, a circular letter was addressed to some forty farmers in various sections of the state, who it was thought might have been trying the crop. Of the twenty-three answers received, six reported that no attempt had been made, fourteen reported total failure, two claimed partial success, and one stated that a good stand had been secured on about two acres of ground.

Failure was attributed to drouth, to poor seed, and to cold. The common statement was but a restating of the experience at the Station. "It came up well, but was mostly killed by the dry weather." It is more than likely that the failures attributed to poor seed were due in reality to the same cause, "dry weather," for crimson clover seed uniformly has a high percentage of germinating power. Few seeds germinate more readily in presence of even slight moisture, and few young plants are more sensitive to drouth. Even a slight shower in the midst of a drouth is sufficient to start the sprouts, most of which soon perish, leaving little patches of green scattered over great stretches of bare field.

In the one successful case reported the seed had been sown alone in September on land that had grown a crop of corn. This was not typical black prairie, but what is locally known in south central Illinois as "hard pan" land, with a stiff impervious clay within 18 inches of the surface. One partial success followed sowing in August on wheat stubble after preparation with a spading harrow; the other was in oats stubble in September, after a cutaway or disk harrow. Neither was on hard pan land.

Of the entire twenty-three correspondents seventeen state definitely that red clover succeeds in their section. Two on hard pan land state that it will not succeed, and one that it fails too often to be profitable; but it is a significant fact that the two others living on hard pan land report red clover as successfully grown.

From this it would seem that crimson clover is in Illinois a far more precarious crop than the red clover in whose stead it was expected to serve.

In addition to other unfavorable reports letters from the Experiment Stations of Ohio, Indiana, and Michigan all reported

practical failure with crimson clover, leading us to infer either that our conditions are not favorable to this crop or else that we have yet to learn how to grow it.

During the season of 1895 much was said about the advantage of using northern grown seed, thereby securing the benefits of acclimation. In the hope of learning to what extent the source of seed might be responsible for failure, the Station secured crimson clover seed from eight representative seedsmen.

One dealer furnished two brands, one of which was warranted extra hardy, and another claimed superior excellence for seed grown in Indiana and supplied for comparison both imported seed and that grown in Delaware. Repeated sowings were made of these eleven samples of seed at different dates and under various conditions but with no better success than formerly and no perceptible difference in the power of plants from particular brands of seed to stand either drouth or cold weather.

Several cases were reported of success from sowings made in July, 1895, and it should be mentioned in this connection that these were coincident with an unusually moist and rainy period of several days, allowing time for the young plants to become established.

#### CONCLUSIONS.

1. Crimson clover is less likely than red clover to succeed in Illinois.
2. Drouth and cold are its great enemies—notably the former, especially in the early life of the plant.
3. If benefits may be had from acclimation, they have not yet become sufficiently established to be noticeable.

E. DAVENPORT, M. AGR., *Director*.

### On the Improvement of Retentive Clays: Drainage of the So-called "Hard pan" Lands of Southern Illinois.

If an irregular line be drawn from the mouth of the Kaskaskia river through Murphysboro in Jackson county and Marion in Williamson county to Carmi in White county, it will mark approximately the southern limits of the first or oldest glacier of Illinois.

Another irregular line running from Terre Haute, Indiana, through Mattoon in Coles county, near Shelbyville in Shelby



county, thence bending to the north and passing west of Decatur in Macon county on its way to Peoria will mark approximately the extreme limits of the second ice sheet which in its descent covered deeply with a mixture of boulder clay, sand, and gravel the older and thinner deposit of finely divided clay left by the first glacier.

Between these boundaries the deposit left by the old glacier lies for the most part still exposed except where tongues from the higher levels of the great prairie intrude upon and overlap it, or where its characteristic features have been obliterated by river systems. So extensive have been the invasions into the domain of this ancient region that the white clay tracts are chiefly found as they exist to-day on the higher levels south of Mattoon and north of Marion, and between the Kaskaskia River on the west and the Wabash River on the east. The margins of these tracts are everywhere irregular and their features are best preserved at points remote from water courses.

It may be well to say here that the term "hard pan" as referring to this section is a local term meaning only an unusually heavy and retentive clay subsoil, which, when it comes to the surface, constitutes a "scald spot" or "stick." Such subsoils and "stick" spots appear to have a content of iron somewhat above the normal, but have not yet been examined. Let it suffice to say that by "hard pan" is not meant that thin stratum of what is practically rock that commonly goes by the same name and that is totally impervious to water, but that it means simply an uncommonly exaggerated instance of ordinary conditions in this locality.

The characteristic deposit of the old glacier, or at least of so much of it as has been left exposed in this region, is an impalpable clay and sand through which water makes its way so slowly that it is classed as an impervious soil.

There is the greatest difficulty in securing the proper conditions of moisture in such a soil, where, as is usually the case, the land is too nearly level to permit the rains of spring to run off. The soil is so nearly impervious that the water must needs stand upon the land until removed by evaporation. By this time the season is far advanced, and the effect is seen in corn planted later in the southern limits of this area than at the northern end of the state, more than 300 miles distant. Not only that; this same water that encumbered the land in spring and delayed planting was precious; had it soaked away into the ground, it would have remained to check the temperature and to recompense the evaporation of summer. But it has evaporated, its cooling effect was produced when it was a damage and not a benefit, and the natural defense against the summer drouth is gone. It has gone as thor-



oughly as if the surface were rolling and it had run away, with the added disadvantage that slowly evaporating it consumed both heat and time at a season when both were precious.

The land in question has enjoyed an enviable reputation as a wheat producing region, and is a region of great fertility. It is especially adapted to wheat, as that is a crop which requires no spring culture, and is out of the way before the drouth appears. However, the need of more diversified cropping is apparent, not only on account of the low price of wheat and the good of the soil, but because of the fact that all the conditions are perfect for the development and ravages of that destructive pest, the chinch-bug.

The attempt to grow other than winter crops, as wheat and hay, encounters difficulties easily appreciated. It requires spring culture and summer growth, which are impossible except in seasons of moderate spring and copious summer rains.

The natural situation will be better understood by a reference to the following table, which exhibits the physical character of the soil in question, the samples being taken from different localities along a line nearly north and south and compared, by the centrifugal method for mechanical analysis, with a sample of the soil at this Station, which lies on the higher levels of the second glacier.

COMPARATIVE PHYSICAL CHARACTER OF TWO SAMPLES OF WHITE CLAY SOIL AND ONE OF UPLAND PRAIRIE OF SECOND GLACIATION, WITH SUBSOILS OF EACH.

Name of particles.	Size of particles in millimeters.	Odin soil.		Edgewood soil.		Station soil.	
		Surface.	Subsoil 20 in.	Surface	Subsoil 15 in.	Surface.	Subsoil 15 in.
Gravel.....	More than 2	.....	.....	.19	.....	1.02	1.06
Grits.....	2 —.5	1.03	.44	1.64	.72	6.01	6.85
Coarse sand.....	.5 —.2	3.78	1.52	7.66	2.31	23.69	28.71
Fine sand.....	.200—.060	8.38	3.98	7.64	3.72	9.48	9.94
Coarse silt.....	.060—.025	45.01	32.61	45.14	30.40	27.35	23.31
Fine silt.....	.025—.010	19.01	16.48	16.05	12.02	9.75	8.31
Dust.....	.010—.002	11.44	10.08	9.22	10.01	7.96	7.36
Clay.....	Less than .002	10.78	34.44	12.08	39.77	14.57	14.46
		99.43	99.55	99.62	98.95	99.83	100.00
Error.....		.57	.45	.38	*1.05	.17	.00
†Organic matter.....		6.53	6.07	4.12	6.87	7.40	4.90

NOTE.—The percentages are given on the basis of ignited soil.

\*This error is chiefly in grades 4 and 5. Due to accidents.

†Organic matter equals loss on ignition of water-free soil.

The fineness of these lesser particles is inconceivable. Those denominated "clay" are less than one-twelve thousandth of an inch in diameter and the number of particles in a cubic inch of such soil is way up among the billions. Not only that; it will be noticed that of the Station sample 23.69 per cent. of the soil and

28.71 per cent. of the subsoil rank as coarse sand whose particles are between .5 and .2 of a millimeter in diameter. Such immense masses, comparatively speaking, afford clinging room for thousands of the finest ones, and we find that they do so adhere, because the per cent. of clay in this sample is practically the same for soil and subsoil, viz., 14.57 per cent. for soil and 14.46 per cent. for subsoil.

Not so in the two samples from the older glacial soil. There is little of coarse matter in the upper layers to which the finest particles may cling and they seem to have settled gradually into the lower or subsoil. Note that the percentages of clay in soil and subsoil as given in the table are respectively: Odin, 10.78 and 34.44; Edgewood, 12.08 and 39.77. Note also that the sample from the Station is the only one that exhibits much more organic matter in the soil than in the subsoil and that the Edgewood sample shows even less.

The practical question is, what is to be done for such soils? The Station has undertaken certain lines of work looking towards a possible answer, only a portion of which has proceeded sufficiently far to warrant even a preliminary report.

It was seen at once that the fundamental difficulty is one of moisture arising not from excessive or deficient rainfall, but from soil conditions. Soils made up of such finely divided particles possess an immense extent of surface and a correspondingly great capacity for water, if only it can be brought to enter.

The fineness of division is exhibited in another way. When parched with drouth in August, a handful of road dust firmly pressed by the fingers becomes and remains a ball of earth that will endure considerable tossing about. This being true, the air that occupies such soils does not simply rest freely from particles to be easily displaced by some other gas or liquid with a superior gravity. It is not held loosely by entanglement but firmly by adhesion to the great expanse of surface of the infinitely small particles and is not readily displaced. Consequently, when rains come, there is the strongest tendency for the water to stand upon the surface as upon a cushion of air without much contact, precisely as it will upon the surface of flour, stucco, or other finely divided powders.

Underdrainage is a well known remedy not only for soils that are too wet but for those that, although in regions of abundant rainfall, are too dry. A drained soil is not only drier in the spring but is more moist in summer, because of having brought into contact with its particles water which otherwise would have run away or evaporated.

There was no question of the effect of underdrainage if it could be made to operate, but local opinion was nearly unanimous to the effect that water would never reach tiles laid in such soils, particularly in the so-called "hard pan" lands and "scald spots" or "sticks."

It was decided to resort to a test of drainage, and accordingly one of the most refractory spots procurable was selected at Edgewood. The following notes refer to the tiling of an area of one acre.

Three and one-half inch tile were laid two and one-half feet deep in lines 50 feet apart, and the job was finished March 3, 1896. The workmen noted that the digging near a railroad ditch was easier and that the dirt handled more freely there than in other portions of the field.

March 5. Three-fourths inch rain; water flowed from drain three days.

March 23. Five inches of snow; water flowed from tile for seventeen days in succession. The first three days after the snow disappeared the tile flowed one-half full.

April 16 and 17. Plowed all the field, tiled portion was perceptibly driest. On the 16th the Station took samples of both soil and subsoil, in both drained and undrained portions. In digging in the tiled portion at the farthest points from the tile water was not reached till below a depth of two feet and the earth handled freely; but in the undrained part water was found within a foot of the surface and the lower soil was a tenacious mud.

April 20. Three-fourths inch of rain; water flowed from tile.

April 29. Planted all to corn, Kafir corn, cow peas, and buckwheat.

May 26. Two and three-fourths inches of rain.

May 27. Water commenced to flow from tile and continued for three and one-half days.

May 31. Between 1 and 4 A. M. one and three-fourths inches of rain fell, and at 9 A. M. the tile were running three-fourths full and continued to flow for six days.

June 9. Plowed corn; tiled land in best condition.

June 22. One and three-fourths inches rain fell; tile did not start.

June 25. Three and one-fourth inches rain fell during the early part of the night and the next morning the tile were running one-half full.

June 27. One and one-half inches of rain; tile ran five days in all.

June 30. Tiled portion much the driest.



July 15. One and one-half inches rain ; tile did not start.

July 19. Five-eighths inch rain ; tile started but continued only a short time.

October 3. Equal areas of tiled and of undrained land yielded corn and stover as follows : Undrained, 2215 pounds of ears, and 1570 pounds of stover ; tiled, 2711 pounds of ears and 1990 pounds of stover. This is 22 per cent. increase of corn and 26 per cent. increase of stover on the tiled portion.

As a result of the season's labors it has been demonstrated that these lands may be underdrained without difficulty, and the notable increase in yield is no surprise.

It yet remains to learn if drains will endure, but the closest observation has failed to find signs of destruction. But little silt appears at the outlet and none has settled in the tile along the course of the drain. The work will be continued, but the essential question in doubt has been settled, viz.: Could water penetrate these soils and reach tiles laid at a sufficient depth for drainage?

For the benefit of those specially interested, this caution is expressed : Do not be deceived by standing puddles of water. The bottom of the pool has in some way become "puddled" and is impervious. In numerous cases water was found standing in cattle tracks directly over and within two and one-half feet of tile in active operation. *When tiles are laid in these soils, because of their exceeding fineness, the grade must be even, the joints close, and the earth well packed next the tile.*

The experience of the year indicates that 50 feet, or even 100 feet, apart is unnecessarily close for lines of tile even in these so-called impervious soils.

E. DAVENPORT, M. AGR., *Director.*

## On the Importance of the Physiological Requirements of the Animal Body ; Results of an Attempt to Grow Cattle without Coarse Feed.

*Object.*—Some years ago a question arose in the writer's mind regarding the physiological requirements of the animal body as distinct from the chemical, and it suggested the query,—To what extent is it necessary to cater to the instinct and the appetite of the animal in the matter of nutrition?

As a preliminary study an experiment was planned at that time in which the object was to note the effect of withholding



coarse feed from an herbivorous animal. Some work was done but circumstances intervened to prevent its completion, and not until the past year has it been possible to resume a line of investigation which at the outset encountered so many strange and unexpected phenomena.

*Plan.*—In brief, the plan was and has been to attempt to raise a calf to maturity under conditions entirely normal with one exception, viz., the absence of coarse feed of any kind, but with every compensation possible in the way of variety and amount. It may be argued that such an experiment can have no practical value. Indeed, it may be frankly stated that when commenced, it was not with a feeling that much would come of it; but, as the work has progressed, certain facts have seemed to be plainly brought out and so surely and accurately repeated as to indicate the presence and the operation of a general principle that we cannot offend with impunity, and that is that the deep seated needs of constitutional habit are absolute. This principle, if it be a principle, has an exceedingly important economic bearing.

Four experiments have been conducted, all with calves, and all begun immediately after birth. Peculiar difficulties were encountered, and it was not until the second experiment that methods were so far perfected as to control conditions. During that experiment and afterwards accurate notes were kept. For the use of those specially interested these notes are transcribed in full.

EXPERIMENT NO. 1.—As has been stated this experiment was inaugurated a number of years ago, and as no notes are at hand this brief statement covering the principal points of the first experiment is from memory. Early in the spring a grade Short-horn calf was selected and fed freely, at first upon milk, precisely like its fellows. At the first indication of a desire to take coarse food its bedding was removed and shavings substituted. Grain was given at an early age and freely eaten, but there appeared a phenomenal appetite for bulky food, and indications of an unsatisfied appetite. It would freely eat shavings, if allowed, and ropes and bits of lumber were chewed whenever attainable.

All this time, however, the calf was hearty, healthy, and flourishing, and nothing peculiar could be detected except its insatiate desire for anything that was bulky or coarse. It consumed inordinate quantities of ground feed composed of one-half corn and one-half oats, and it seemed that the hulls of the oats would afford sufficient bulk to satisfy the appetite for coarse material, especially as he came to take more than a half bushel daily before he was five months of age.

In its eagerness for something more or something different in the way of food earth was freely eaten, if available; but as this habit is a normal one with horses and as all cattle evince an abnormal appetite for anything that may be chewed, the calf was closely watched to see whether these peculiarities might not ultimately disappear and the animal settle down to its regular food and become accustomed to, and satisfied with, a non-herbivorous diet. This it never did.

At about four months the joints commenced to swell and the legs to stiffen; later by spells the calf walked with a reeling motion, although at other times he played as would any other calf. One of the most peculiar facts noticeable was the body conditions as to flesh. It was poor, but not thin. Its muscles remained plump and exceedingly firm not to say solid to the touch.

At about five months there was an evident disturbance of the nerve centers, and, although the calf never missed a meal or suffered from disturbed digestion, it was evident that it could not long survive. It was at this time taking over a half bushel of grain daily with evident relish. It was now killed and a postmortem examination revealed nothing peculiar in the development of the internal organs. A great quantity of food was found in the stomachs, but there was no sign of inflammation, or of internal disturbance of any kind. The one noteworthy feature of the carcass was the absolute lack of fat, either external, or internal. This, together with the plumpness of the muscles, left the outlines of each clearly defined and not obscured as is the case in normal specimens in which the connective tissue even in thin animals carries considerable fat.

EXPERIMENT NO. 2.—Calf the offspring of a high grade Holstein-Friesian cow and a Jersey bull, dropped June 17, 1895, and weighed at birth 107 pounds. After the sixth day he was put on a diet of skimmed milk alone, of which he consumed 950 pounds before the first of August, or 25 pounds per day.

During the month of August he consumed 1130 pounds of milk, did very well and weighed at the end of the month 197 pounds. In 69 days the calf had gained 90 pounds at the expense of 2080 pounds of skimmed milk, or in the proportion of 1 to 23. He had evinced a strong appetite for coarse food and was kept well muzzled.

September.—Milk consumed, 1300 pounds; weight, 245 pounds; gain, 48 pounds, or nearly 1 to 27. Calf vigorous and has a ravenous appetite; bawls for food and is not satisfied even with 50 pounds of milk a day.

October.—Milk consumed, 1600 pounds; weight, 285 pounds; gain, 40 pounds, or 1 to 40. A pronounced stiffness in the joints.

November.—Milk consumed, 1533 pounds; weight, 291 pounds;

gain, 6 pounds, or 1 to 255. Stiffness increasing and accompanied by a lessened activity and appetite. No longer appears restless and no longer bawls for food.

December.—Milk consumed, 1313 pounds; weight, 297 pounds; gain, 6 pounds, or 1 to 219. Calf in a bad condition, very stiff and with very little inclination to move. Seemed indifferent as to whether it eats or not and is not found up awaiting its food.

January.—Up to the 11th of the month the calf drank 250 pounds of milk and weighed 333 pounds, having apparently gained 36 pounds in eleven days on 250 pounds of milk, or 1 to 7. *Seven months on an exclusive diet of skimmed milk.*

January 11.—Calf refused to get up or to take milk. It did not hold its head up and seemed nearly dead. At 8 o'clock A. M. hay and straw were put before it and it ate greedily, evincing no choice between the two, and at 11 o'clock A. M., three hours after taking coarse food, it was ruminating for the first time in its life and exhibited a brightened eye and a most contented expression of countenance. Before night it was standing up and moving about. Drank  $6\frac{1}{2}$  pounds of milk.

January 12.—Morning: Calf ate hay and straw thirty minutes and drank  $5\frac{1}{2}$  pounds of milk. Evening: It ate hay and straw thirty-five minutes and drank  $14\frac{1}{2}$  pounds of milk.

January 13.—Ate  $1\frac{1}{2}$  pounds of hay and drank 16 pounds of milk. Greatly improved.

January 14.—Hay, 2 pounds; milk, 23 pounds.

January 15.—Hay,  $2\frac{1}{4}$  pounds; milk, 27 pounds.

January 16.—Hay,  $1\frac{1}{2}$  pounds; milk, 17 pounds.

January 17.—Hay, 1 pound; milk, 19 pounds.

January 18.—Hay, 1 pound; milk, 26 pounds.

January 19.—Hay,  $1\frac{3}{4}$  pounds; milk, 29 pounds.

January 20.—Hay,  $1\frac{3}{4}$  pounds; milk, 34 pounds. Legs straightening.

January 21 to 28.—Hay, 10 pounds; milk, 120 pounds; oats, 12 pounds. Improving.

January 28 to February 4.—Hay, 11 pounds; milk, 131 pounds; oats, 13 pounds. Weighed 343 pounds.

February 4 to 11.—Hay,  $12\frac{1}{2}$  pounds; milk, 140 pounds; oats, 11 pounds; weight, 350 pounds; gain, 7 pounds. Improving.

February 12.—Took first play in pen for four months.

February 11 to 18.—Hay,  $16\frac{1}{2}$  pounds; oil meal, 5 pounds; milk, 200 pounds; weight, 365 pounds; gain, 15 pounds.

February 18 to 25.—Hay, 20 pounds; oil meal, 6 pounds; oats,  $18\frac{1}{2}$  pounds; milk, 360 pounds; weight, 370 pounds; gain, 5 pounds. Very playful in pen.



February 25 to March 3.—Hay, 14 pounds; oats, corn, and wheat, equal parts mixed, 9 pounds; milk, 200 pounds; weight, 385 pounds; gain, 15 pounds. Improving wonderfully and getting straight in the joints.

March 3 to 10.—Hay, 20 pounds; oats, bran, ground corn, and wheat mixed in equal parts, 18 pounds; milk, 240 pounds; weight, 406 pounds; gain, 21 pounds.

March 10 to 17.—Hay, 18 pounds; mixed feed as above, 20 pounds; milk, 300 pounds.

March 17 to 24.—Hay, 20 pounds; mixed feed, 40 pounds; milk, 300 pounds.

March 31.—Ate during last seven days 35 pounds mixed feed with milk, hay, and silage at will, and was in every respect well, hearty, and growing, and as able and as disposed to be active as was any calf in the barn. Experiment closed.

This was practically a case of raising from the dead, and to those who watched intently the decline and the recovery it was a lasting lesson upon the requirements of constitutional habit.

EXPERIMENT NO. 3.—Grade Jersey dropped May 1, 1896. Deprived of coarse food.

Record of feed and weights in pounds.

Date.	Milk.	Weight.	Gain.	Remarks.
May 1 to June 1 .....	594	...	...	
June 1 to 17 .....	419	135	...	
June 17 to 24 .....	182	151	16	Doing well.
June 24 to July 1 .....	252	155	4	Good appetite and plenty of life.
July 1 to 8 .....	224	162	7	
July 8 to 15 .....	229	164	2	Plenty of life.
July 15 to 22 .....	240	184	20	Good appetite but reeling walk.
July 22 to 29 .....	301	187	3	Good appetite but getting weak.
July 29 to August 5 .....	400	192	5	
August 5 to 12 .....	444	198	6	Doing well.
August 12 to 19 .....	410	200	2	Straight and smooth; joints all right as yet.
August 19 to 26 .....	500	215	15	Plays freely.
August 26 to September 2 .....	540	217	2	
September 2 to 9 .....	500	265	48	
September 9 to 16 .....	517	260	-5	Doing well.
September 16 to 23 .....	447	...	..	

Note here says that calf is not doing well and seems not to be satisfied with its food, although it has been taking more than 70 pounds of milk per day for over a month.



Date.	Milk.	Grain.	Remarks.
September 24.....	41½		
" 25.....	47		
" 26.....	32½		
" 27.....	40		
" 28.....	30	4	Equal parts corn and oats.
" 29.....	36½	6½	
" 30.....	42	7	Weight, 271 pounds.
October 1.....	50½	8	Doing well.
" 2.....	32	8	
" 3.....	23½	5½	
" 4.....	37½	4	
" 5.....	42	7	
" 6.....	47½	6½	
" 7.....	10	0	Weight, 258 pounds.

Not doing well and given some hay ; five and one-half hours before ruminating was begun.

Date.	Milk.	Hay.	Grain.	Remarks.
October 8.....	8	2½	3	Mixed as above.
" 9.....	9½	2	5½	
" 10.....	21	1¾	4	
" 11.....	22½	2½	3¾	
" 12.....	21¾	1	2½	Calf greatly improved.

From here on the experiment may be considered as closed, for it enjoyed a mixed feed like other calves, and speedily fully recovered. Like its predecessors the first symptom of approaching starvation, for that is what the effect of such a diet most resembles, was an increased appetite and an enormous consumption of food that seemed not to satisfy. Later, however, when the symptoms were fully developed, the animal seemed entirely indifferent to food.

EXPERIMENT NO. 4. High grade Jersey. To be weaned early and put on an exclusive diet of grain.

June 3, 1896.—Calf two weeks old and taking 20 pounds of milk daily.

Date.	Milk.	Grain.	Bran.	Oats.	Water.	Weight.	Gain.	Remarks.
June 17	280	.....	.....	.....	.....	107	.....	
June 24	280	17½	.....	.....	.....	112	5	Grain equal parts by weight, corn, oats, and wheat ground.
July 1	280	21	.....	.....	.....	122	10	
July 8	280	21	.....	.....	.....	130	8	
July 15	210	10	.....	.....	.....	137	7	Grain equal parts by weight, corn and oats ground.
July 22	140	17½	.....	.....	.....	150	13	
July 29	98	13	.....	.....	.....	152	2	
August 5	84	20	15	.....	.....	144	-8	Getting poor.
August 12	40	22½	18½	4	30	145	1	Not doing well.
August 19	0	20	10	7	21½	143	-2	Had 3 lb. oil cake.
August 26	0	17½	4	15	0	135	-8	2½ lb. oil cake.
September	0	10¾	.....	16	0	120	-15	Appetite not good.

Note here says that calf has no desire for food and will not get up.

September 5.—Calf took a little milk; has refused water for two weeks.

September 6.—Calf drank 8 pounds of milk and seemed to enjoy it.

September 7.—Refused milk in the morning, but drank 3 pounds in the afternoon.

September 8.—Refused all food.

September 9.—Drank 8 pounds of milk and ate 3 pounds of oats. Bloated badly. It weighed now 167 pounds and had apparently gained 24 pounds since August 20th, when it refused water and since which time it had drunk but 19 pounds. It weighed 47 pounds more than on September 3d, when it refused all food and drink and since which time it had consumed but 3 pounds of oats and 19 pounds of milk, not counting the few swallows recorded as "a little."

The query is as to the source of this gain, and it would be most readily chargeable to error were it not that a like increase had been noted in both No. 2 and No. 3 at a similar stage in the experiment.

September 10.—Drank 4 pounds of water and ate 2 pounds of bran.

September 11.—Drank 12 pounds of water and ate 4 pounds of mixed grain. Appetite is better and the calf seems to be improving.

September 12.—Water, 23½ pounds; mixed grain, 4 pounds.

September 13.—Water, 27 pounds; bran, 1½ pounds; whole oats, 2 pounds.

September 14.—Water, 28 pounds; bran, 2 pounds; oats, 3 pounds.

September 15.—Water, 17½ pounds; mixed grain, 7 pounds.

September 16.—Water, 9½ pounds; mixed grain, 6¾ pounds.

With this increase of appetite and brightened appearance it looked as if this calf would, as had its predecessors, rally for a time at least without hay, but almost without warning it sickened and died. This was the first calf to show signs of a disturbed digestion.

#### DISCUSSION.

A close study of these animals, their feed, gains, and attendant symptoms discloses certain peculiar and not a few abnormal and puzzling facts.

RUMINATION.—From the first it had been a query whether anything like normal rumination would follow the consumption of

coarse grains like bran or oats in the absence of coarser food; but the closest observation failed to discover it until hay or straw was taken. No. 2 was contentedly chewing his cud for the first time at 7 months of age, 3 hours after his first meal of hay. With No. 3 it was not until  $5\frac{1}{2}$  hours after the first meal of hay that rumination was noticed, and Nos. 1 and 4 never ruminated.

ABSENCE OF FAT AND CHARACTER OF FLESH.—The total absence of fat either internal or external as revealed on post-mortem examination, particularly after the enormous amounts of food consumed, is unaccountable. No. 1 at six months of age was taking about  $\frac{1}{2}$  bushel of mixed grain per day, yet no fat was to be found even about the kidneys. But the muscles were not shrunken; on the contrary, they were plump and exceedingly dense. The animals would all attract instant attention. At a glance they looked poor, yet they were not thin like those that have suffered from insufficient food. Upon touching with the hand it would be noted instantly that the muscles were exceedingly hard, and that the general appearance of the animals is approached by those only that have been long on dry pasture with insufficient water.

ENORMOUS CONSUMPTION OF FOOD.—These experiments serve an important purpose in showing that the amount of food that is consumed is no indication of its economic use, and that enormous amounts may be taken in the vain attempt to satisfy an abnormal appetite. These animals were wanting something that they could not get, and with the appetite of the first stages of dyspepsia, ate everything in sight. This is one of the symptoms of insufficient nutrition, which is but another name for the early stages of starvation, and is a condition of things that the careless feeder often brings upon his stock by poor care or insufficient food in early winter. That the rally, if made at all, will be made at great expense of food is more clearly shown in these experiments than by data heretofore possessed.

No. 1 ate at six months of age a half bushel of mixed grain per day. At two months of age No. 2 ate 40 pounds of milk daily and rose to over 50 pounds at four months, which proved inadequate to its wants. After being allowed hay the same calf made gains amounting to from 2 to 3 pounds a day on a ration of from 2 to 3 pounds of hay,  $2\frac{1}{2}$  to 3 pounds of grain, and 30 to 35 pounds of milk. No. 3 went to pieces at between four and five months after consuming an average of  $71\frac{1}{2}$  pounds of milk daily for five weeks. This is 35 quarts per day, and it seems almost inconceivable that a Jersey calf, at less than four months, could consume so much.



**NON-DISTURBANCE OF DIGESTION.**—It would seem that such inordinate amounts of food must destroy a calf or at least lead to complicated disturbances within the machinery of digestion. In none but the last (No. 4) was any disorder of the kind noted. The bowels remained regular throughout and the droppings appeared normal. It raises a query as to the extent to which digestion was really accomplished and whether failure was primarily in the digestive apparatus, or in the metabolic processes of the body.

**GAINS.**—Some of the gains secured are worth noting. No. 2 in the first 100 days gained 138 pounds on 3380 pounds of skimmed milk, or 1 pound of gain for 25 pounds of milk. The same calf increased from 107 pounds to 333 pounds at seven months, a gain of 226 pounds, on an exclusive diet of skimmed milk. But the limit was reached and gains as high as 3 pounds per day were made later on a moderate feed of hay, grain, and milk. No. 3 gained less on his diet of milk and in 90 days gained 109 pounds on 4739 pounds of milk, or 1 pound of gain for 43 of milk. No. 3, although much smaller than No. 2, ate more milk, as will be seen, and put on less gain.

**SUDDEN APPARENT HEAVY GAINS.**—It will be remembered that No. 2 appeared to have gained 36 pounds in the eleven days just before its collapse; that No. 3 apparently gained 48 pounds in the seven days from September 2d to 9th and went "off" immediately after, and that No. 4 September 9th weighed 47 pounds more than it did six days before, although it could not have consumed in the meantime more than that amount of food. Some allowance must be made for the inaccuracy of gains computed from a difference in consecutive weights and an error in weights is always possible; but the substantial agreement, in all cases, in a sudden and extreme increase of weight just before a collapse is, to say the least, surprising and difficult of explanation, especially in the case of No. 4, in which the material appears to be wanting. The difficulty is not lessened by the fact that this occurred once and once only with each calf.

**UNIFORMITY OF SYMPTOMS.**—All agreed substantially in the essential symptoms resulting from deprivation of coarse food; viz., a ravenous appetite followed by enlargement and stiffening of joints, spells of dizziness and difficult locomotion, all followed by periods of relief and, finally, by a settled feeling of indifference to food. This indifference could be removed temporarily by any change of food, but permanently by coarse food only, which never failed to effect a restoration to normal conditions.

**STARVATION.**—These experiments considered in connection with common observation and experience seem to teach that



whether food be insufficient in quantity or imperfectly adapted in quality to the needs of the animal the result is the same, defective nutrition, which is in no sense different from starvation.

It may be argued that depriving milk of its fat violated a law of nature. The teaching has been, however, that the casein would be a full equivalent if in sufficient quantity, and the fact is clear that all these calves that were put on a diet of skimmed milk flourished remarkably well till at the age of four or five months.

However that may be, they all failed to sustain the demands of life on any diet until a ration of hay or straw was added and then, as in the case of Nos. 2 and 3, made a rapid recovery. Further, from the first the attendant symptoms were those characteristic of slow starvation; viz., a ravenous appetite soon giving place to a disturbance of the nerve centers and, later, an entire indifference to food and a total loss of appetite.

As starvation in mature animals is accompanied by a wasting of the tissues, especially fat, so here starvation by imperfect nutrition during development resulted in the total absence of fat.

As bearing upon the more general principles of physiological requirements and body behavior, it may be said that these calves have exhibited phenomena notably similar to those of ill-fed children, as they have been studied by the writer in the tropics and observed to some extent in certain quarters of great cities. In hot countries a very little food will sustain life in a mature body, but the demands of growing children are more exacting and they may be seen by hundreds tucked away in obscure corners, with face in hands, exhibiting that characteristic expression that may be called the starved look and that is easily detected in human being or in animal wherever present.

There is a popular belief that starvation in all its stages is an acute and painful condition incident only upon insufficient amounts of food. There could be no greater error. The acute stage soon passes and there is only a nameless and dull yearning left till life is extinct. These experiments appear to teach that starvation partial or complete may ensue upon an apparently slight interference with constitutional habit.

E. DAVENPORT, M. AGR., *Director.*

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